

WHAT IS CLAIMED IS:

1. An illumination apparatus comprising:
an inner-surface reflecting type integrator;
5 an optical system for directing a beam from a light source to a portion of incidence of said inner-surface reflecting type integrator;
an wave-front splitting type integrator;
an image-forming optical system for arranging the portion of incidence of said inner-surface reflecting type integrator approximately conjugate
10 with a portion of incidence of said wave-front splitting type integrator, and for directing a beam from said beam mixer to said wave-front splitting type integrator; and
an irradiating optical system for superimposing multiple beams from said wave-front splitting type integrator on a plane to be irradiated, wherein
15 a stop is provided at or near the portion of exit of said inner-surface reflecting type integrator.
2. An illumination apparatus according to claim 1, wherein said inner-surface reflecting optical integrator reflects at least a part of incident light with an internal surface of said inner-surface reflecting optical integrator, and for
20 forming a surface light source on or near the plane of exit of said inner-surface reflecting optical integrator.
3. An illumination apparatus according to claim 1, wherein said wave-front splitting type integrator is a lens array for splitting a wave front of incident light, and for forming multiple secondary light sources on or near the
25 portion of exit of said wave-front splitting type integrator.
4. An illumination apparatus according to claim 1, wherein said stop is a mechanical aperture stop.
5. An illumination apparatus according to claim 1, wherein said stop
30 is made of a light shielding material applied onto the portion of exit of said inner-surface reflecting type integrator.

6. An illumination apparatus according to claim 1, wherein said stop is made of a multi-layer film vapor-deposited onto the portion of exit of said inner-surface reflecting type integrator.
7. An illumination apparatus according to claim 1, wherein said stop
5 is made of a metallic film vapor-deposited onto the portion of exit of said inner-surface reflecting type integrator.
8. An illumination apparatus according to claim 1-7, wherein said image-forming system is a zoom optical system.
9. An illumination apparatus according to claim 1 or 8, wherein the
10 portion of exit of said inner-surface reflecting type integrator has a polygonal shape, and said stop has an aperture for correcting σ anisotropy.
10. An illumination apparatus according to claim 9, wherein said stop has an approximately circular aperture.
11. An illumination apparatus according to claim 9, wherein said stop
15 has apertures having an approximately equal diameter at least in four directions of 0° , 45° , 90° , and 135° .
12. An illumination apparatus comprising;
an inner-surface reflecting type integrator including a portion of
exit with an n-gonal shape where n is a natural number;
20 a wave-front splitting type integrator;
a zoom optical system for projecting an image of the portion of exit
of said inner-surface reflecting type integrator, onto a portion of incidence of said
wave-front splitting integrator; and
an irradiating optical system for superimposing multiple beams
25 from said wave-front splitting integrator on a plane to be irradiated, wherein a
stop having an approximately circular aperture is provided at or near the portion
of exit of said inner-surface reflecting type integrator.
13. An illumination apparatus comprising;
an inner-surface reflecting type integrator including a portion of
30 exit with a n-gonal shape where n is a natural number;

a first condensing optical system for condensing a beam from a light source near a portion of incidence of said inner-surface reflecting type integrator;

a wave-front splitting type integrator;

5 a zoom optical system for projecting an image of the portion of exit of said inner-surface reflecting integrator, onto a portion of incidence of said wave-front splitting type integrator; and

a second condensing optical system for condensing a beam from an irradiating optical system for superimposing multiple beams from said wave-front
10 splitting type integrator on a plane to be irradiated, wherein there is provided a stop having an aperture with an approximately $2n$ -gonal shape where n is a natural number at or near a portion of incidence of said inner-surface reflecting type integrator.

14. A projection exposure apparatus comprising:

15 an illumination apparatus for illuminating a mask located on a plane to be illuminated; and

a projection optical system for projecting a pattern on said mask onto a wafer,

wherein said illumination apparatus comprising:

20 an inner-surface reflecting type integrator;

an optical system for directing a beam from a light source to a portion of incidence of said inner-surface reflecting type integrator;

an wave-front splitting type integrator;

25 an image-forming optical system for arranging the portion of incidence of said inner-surface reflecting type integrator approximately conjugate with a portion of incidence of said wave-front splitting type integrator, and for directing a beam from said beam mixer to said wave-front splitting type integrator; and

30 an irradiating optical system for superimposing multiple beams from said wave-front splitting type integrator on a plane to be irradiated, wherein

a stop is provided at or near the portion of exit of said inner-surface reflecting type integrator.

15. A projection exposure apparatus comprising:
an illumination apparatus for illuminating a mask located on a
5 portion to be illuminated; and
a projection optical system for projecting a pattern on said mask
onto a wafer,
wherein said illumination apparatus comprising:
an inner-surface reflecting type integrator including a portion of
10 exit with an n-gonal shape where n is a natural number;
a wave-front splitting type integrator;
a zoom optical system for projecting an image of the portion of exit
of said inner-surface reflecting type integrator, onto a portion of incidence of said
wave-front splitting integrator; and
15 an irradiating optical system for superimposing multiple beams
from said wave-front splitting integrator on a plane to be irradiated, wherein a
stop having an approximately circular aperture is provided at or near the portion
of exit of said inner-surface reflecting type integrator.

16. A projection exposure apparatus comprising:
20 an illumination apparatus for illuminating a mask located on a
portion to be illuminated; and
a projection optical system for projecting a pattern on said mask
onto a wafer,
wherein said illumination apparatus comprising:
25 an inner-surface reflecting type integrator including a portion of
exit with a n-gonal shape where n is a natural number;
a first condensing optical system for condensing a beam from a
light source near a portion of incidence of said inner-surface reflecting type
integrator;
30 a wave-front splitting type integrator;

a zoom optical system for projecting an image of the portion of exit of said inner-surface reflecting integrator, onto a portion of incidence of said wave-front splitting type integrator; and

5 a second condensing optical system for condensing a beam from an irradiating optical system for superimposing multiple beams from said wave-front splitting type integrator on a plane to be irradiated, wherein there is provided a stop having an aperture with an approximately $2n$ -gonal shape where n is a natural number at or near a portion of incidence of said inner-surface reflecting type integrator.

- 10 17. A device fabrication method comprising the steps of:
projecting a pattern on a mask onto a wafer by using a projection exposure apparatus; and
developing said wafer to which said pattern was transferred,
wherein said projection exposure apparatus comprising:
15 an illumination apparatus for illuminating a mask located on a plane to be illuminated; and
a projection optical system for projecting a pattern on said mask onto a wafer,
wherein said illumination apparatus comprising:
20 an inner-surface reflecting type integrator;
an optical system for directing a beam from a light source to a portion of incidence of said inner-surface reflecting type integrator;
an wave-front splitting type integrator;
an image-forming optical system for arranging the portion of
25 incidence of said inner-surface reflecting type integrator approximately conjugate with a portion of incidence of said wave-front splitting type integrator, and for directing a beam from said beam mixer to said wave-front splitting type integrator; and
an irradiating optical system for superimposing multiple beams
30 from said wave-front splitting type integrator on a plane to be irradiated, wherein

a stop is provided at or near the portion of exit of said inner-surface reflecting type integrator.

18. A device fabrication method comprising the steps of:
projecting a pattern on a mask onto a wafer by using a projection
5 exposure apparatus; and
developing said wafer to which said pattern was transferred,
wherein said projection exposure apparatus comprising:
an illumination apparatus for illuminating a mask located on a
plane to be illuminated; and
10 a projection optical system for projecting a pattern on said mask
onto a wafer,
wherein said illumination apparatus comprising:
an inner-surface reflecting type integrator including a portion of
exit with an n-gonal shape where n is a natural number;
15 a wave-front splitting type integrator;
a zoom optical system for projecting an image of the portion of exit
of said inner-surface reflecting type integrator, onto a portion of incidence of said
wave-front splitting integrator; and
an irradiating optical system for superimposing multiple beams
20 from said wave-front splitting integrator on a plane to be irradiated, wherein a
stop having an approximately circular aperture is provided at or near the portion
of exit of said inner-surface reflecting type integrator.

19. A device fabrication method comprising the steps of:
projecting a pattern on a mask onto a wafer by using a projection
25 exposure apparatus; and
developing said wafer to which said pattern was transferred,
wherein said projection exposure apparatus comprising:
an illumination apparatus for illuminating a mask located on a
plane to be illuminated; and
30 a projection optical system for projecting a pattern on said mask
onto a wafer,

wherein said illumination apparatus comprising:

an inner-surface reflecting type integrator including a portion of exit with a n -gonal shape where n is a natural number;

5 a first condensing optical system for condensing a beam from a light source near a portion of incidence of said inner-surface reflecting type integrator;

a wave-front splitting type integrator;

10 a zoom optical system for projecting an image of the portion of exit of said inner-surface reflecting integrator, onto a portion of incidence of said wave-front splitting type integrator; and

a second condensing optical system for condensing a beam from an irradiating optical system for superimposing multiple beams from said wave-front splitting type integrator on a plane to be irradiated, wherein there is provided a stop having an aperture with an approximately $2n$ -gonal shape where n is a natural
15 number at or near a portion of incidence of said inner-surface reflecting type integrator.